Rachel's Environment & Health News

#163 - Superfund -- Part 3: Cleaning Groundwater More Difficult Than EPA Initially Thought It Would

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Continuing our series on Superfund cleanups. Page numbers in our text refer to pages in the latest report from Congress's Office of Technology Assessment (OTA), cited in our last paragraph, below.

Groundwater is water that resides underground. Contrary to some popular beliefs, most groundwater is not rushing along in underground rivers. (In some limestone caves, there may be occasional small underground rivers, but such rivers do not occur elsewhere.) The vast majority of groundwater occurs not as rivers but as a huge underground lake. Groundwater does move, but only very slowly. Fast-moving groundwater may move one foot per day; slow-moving groundwater may move one foot per year. Groundwater moves because it is pulled by gravity, and its ultimate destination is the nearest ocean. Once in the ocean, it evaporates (because of sunlight), forms clouds, moves over the land, rains down, sinks into the ground, becomes groundwater, and starts moving slowly toward the ocean again. That is the "hydrologic cycle." As we saw in RHWN #155, there is 40 times as much groundwater below the earth's surface as there is in all the world's lakes and rivers.

Any place where groundwater can be pumped to the surface in quantities that are useful to humans is called an "aquifer."

The surface of the groundwater (the surface of the underground lake) is called the "water table" and it resides about 30 feet below the surface of the ground. Thirty feet is the average depth, but the depth varies considerably from place to place. When the water table sits on the surface of the land, we call that a swamp. In some places--particularly in the far western states--the water table may be several hundred feet below the surface. The earth below the water table is called the "saturated zone" because there the spaces ("pores") between soil (or rock) particles are filled with water; the earth above the water table is called the "vadose zone" or the "unsaturated zone."

In many places, groundwater and surface water intermingle. Groundwater can feed streams by welling up from below, or pushing into a stream from its sides; likewise, streams can lose water from their bottom and sides, feeding the groundwater. These relationships can change with the seasons and can vary from year to year, depending on local and regional rainfall. The nature of the connections between surface water and groundwater in a particular place can be determined by hydrologists who study the local situation carefully and thoroughly and for a sufficiently long time to notice seasonal and annual variations. Usually such study will require the drilling of wells and the taking of water samples to determine the direction and speed of water flows.

When groundwater becomes contaminated, it does not cleanse itself as surface water tends to do. The turbulent action of a flowing river, which mixes oxygen into river water and tends to dilute contaminated water with clean water, is absent in groundwater flows. Likewise, there are fewer bacteria in contact with groundwater, compared to surface water, so bacterial action does not cleanse groundwater as it might surface water. Furthermore, groundwater does not have the benefit of sunlight, and it is also relatively cool. For all these reasons, contaminated groundwater tends to remain contaminated for long periods of time measured in decades or centuries or aeons. On a normal human time scale, groundwater contamination can be considered permanent.

Half of all the people in the U.S. derive their drinking water supplies from groundwater. Because of connections between groundwater and surface water, contaminated groundwater can affect the quality of surface waters and can thus impact wildlife (including fish, and mammals that rely on surface water for drinking). Therefore, groundwater is an essential ingredient for life, a national resource that should be protected.

When Congress passed the Superfund law in 1980, part of the goal of the program was to clean up contaminated groundwater. The U.S. Environmental Protection Agency (EPA) took an optimistic view of the problem and began using "pump and treat" technology at many contaminated sites. Pump and treat means that groundwater is pumped to the surface and treated in some fashion to remove contaminants. The assumption is that the contamination will be pumped to the surface with the water and can then be treated by some process to remove it or detoxify it. The resulting clean water can then be returned to the groundwater via an injection well.

The EPA still takes an optimistic view of "pump and treat" but a large body of scientific evidence has now accumulated showing that pump and treat does not work and--given today's knowledge--cannot work. The latest Superfund study by the Congress's Office of Technology Assessment (OTA) discusses the disappointing record of achievement by "pump and treat" technology (see pgs. 151-157).

The OTA study, citing many scientific papers, makes the following points about "pump and treat":

1) Much contamination attaches itself to soil particles. Therefore, using water samples to estimate the amount of contamination will result in major underestimates of the size of the problem because most of the contamination isn't in the water but is attached to the soil. The contamination detaches itself from the soil and joins the water only very slowly, thus requiring an exceedingly long pumping program-- perhaps hundreds of years--before all the contamination is pumped to the surface.

2) The soil and rock formations below ground are not uniform. Mathematical models of groundwater flow are built on the assumption of some "average" flow rate through the entire aquifer. However, because groundwater flows rapidly through some places and slowly through other places, pump and treat programs will take a long time to flush contamination out of areas where water-flow is slow. Calculations of "average" flow rates greatly underestimate the time it will take to flush contaminants out of the parts of an aquifer through which water moves slowly.

3) "Using current site investigation and remediation technologies, it is not possible to locate all significant contamination, nor can anyone accurately predict contaminant movement, fate, exposure, or remedial technology performance." (pg. 151)

4) Particularly difficult to clean up are contaminants that do not mix readily with water (such as oils), especially those that are heavier than water and thus tend to sink rather than float on the water table. Contaminants in this category include chlorinated solvents (such as trichloroethylene, or TCE), creosote, and PCB-rich oils. Very little success has been achieved in even locating such contaminants, much less in removing them. In general, it is appropriate to view pump and treat programs for these contaminants as "remediation in perpetuity" (pg. 153). That is to say, we should expect to have to pump and treat into the foreseeable future with no end in sight.

The implications of all this are profound. Pump and treat may prevent contamination from spreading, because pumping disrupts the normal flow of groundwater (which is toward the ocean) and thus can prevent the spread of contaminants to new areas, which is good. On the other hand, if most of the contamination is not being removed by pump and treat, some day the money will run out for maintaining the pumps; on that day the contamination will resume its natural movement and citizens may be threatened. It is therefore important to recognize that pump and treat is not a permanent remedy; after the pump is turned off, the problem will then have to be addressed by some different (hopefully permanent) cleanup technology. (On permanent cleanup technologies see RHWN #150). We must ask, instead of pump and treat, does digging up the wastes make sense, removing the soil and chemically (or thermally) processing it to detoxify the contaminants? Citizens must now explore these alternatives wherever pump and treat programs are under way or are contemplated.

Two excellent sources of information on groundwater:

David W. Miller, editor, WASTE DISPOSAL EFFECTS ON GROUNDWATER (512 pages; this 1977 book is now officially out of print, but is still available for $18 from Geraghty & Miller, 125 East Bethpage Rd., Plainview, NY 11803; phone (516) 249-7600.

U.S. Environmental Protection Agency, HANDBOOK: GROUND WATER (Washington, DC: U.S. Government Printing Office, 1987). Available free from U.S. Environmental Protection Agency (U.S. EPA) Office of Research and Development, Publications Office, 26 West MLK Drive, Cincinnati, Ohio 45268; phone (513) 569-7562; ask for EPA Technology Transfer Publication 625/6-87/016.

Get: U.S. Congress, Office of Technology Assessment, CLEANING UP: SUPERFUND'S PROBLEMS CAN BE SOLVED (Washington, DC: U.S. Government Printing Office, 1989). Available for $10 from U.S. Government Printing Office, Washington, DC 20402-9325; request GPO stock No. 052-00301166- 2. Phone (202) 783-3238. Charge it to Visa, Mastercard or Choice.

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